Land surface temperature through satellite imagery

Here I show a summary of the step-by-step instructions for obtaining Earth surface temperature (LST) data using satellite imagery. The results obtained here represent an initial step for several types of more detailed studies.

Applications of this type of information are diverse, and encompass several subjects in the environmental, agrarian, climatological areas and all subjects that make a combination between these important areas of knowledge.

I worked with images obtained from the OLI / TIRS sensors (Operational Land Imager / Thermal Infrared Sensor), on board the Landsat-8 satellite. I followed the steps as shown in a scientific paper ("Algorithm for actomated mapping of land surface temperature using Landsat 8 Satellite Data"), by Avdan and Jovanovska, 2016, already with simplifications of some of the equations.

First, I downloaded the entire "package" of available images, through the USGS page. Practically within every step (in which there is calculation), I used the *raster calculator*, a tool found in any GIS software. I used Spring software (v. 5.5.6) for initial pre-processing of contrast adjustment (for the image with RGB composition) and for other steps I used QGIS (v. 3.10.4).

Main steps and by-products

1 - Determination of radiation from the top of the atmosphere (RTA)

$$RTA = Fmb10 * \text{“B10”} + Fab10$$

Fmb10 = multiplicative factor of band 10

B10 = band 10 (thermal band)

Fab10 = Additive factor of band 10

Note: the band 10 factors can be found in the metadata, obtained in the "package" of the OLI sensor products, as shown below:

RADIANCE_MULT_BAND_10 = 3.3420E-04

RADIANCE_ADD_BAND_10 = 0.10000

2 - Conversion of RTA to brightness temperature (BT)

$$BT = (K2 / \ln (K1 / \text{”TOA”}) + 1)) - 273.15$$

K1 = Band-specific thermal conversion constant (metadata)

K2 = Band-specific thermal conversion constant (metadata)

GROUP = TIRS_THERMAL_CONSTANTS:

K1_CONSTANT_BAND_10 = 774.8853

K2_CONSTANT_BAND_10 = 1321.0789

3 - Determination of NDVI vegetation index

$$NDVI = (NIR - R) / (NIR + R)$$

NIR = Near infrared band (B05)

R = Red band (B04)

4 - Determination of the proportion of vegetation (Pv)

$$Pv = ((NDVI - NDVImin) / (NDVImax - NDVImin)) ^ 2$$

NDVImin = minimum NDVI value

NDVImax = maximum NDVI value

5 - Determination of the emissivity of the Earth's surface (E)

$$E = 0.004 * \text{“Pv”} + 0.986$$

6 - Determination of land's surface temperature (LST)

$$LST = (\text{“BT”} / (1 + (0.00115 * \text{“BT”} / 1.4388) * Ln (\text{“E”})))$$

The results found did not undergo any validation. However, it is already possible to notice the differences between the areas of native vegetation (darker green), agricultural areas and bare soil, identifiable through the composition in natural colors.

The areas of native vegetation had the lowest temperatures (close to 25 ºC), while the areas with exposed soil had the highest temperatures, around 37 ºC.

References

Avdan U, Jovanovska G Algorithm for automated mapping of land surface temperature using Landsat 8 Satellite Data. (2016) Journal of Sensors. Hhtp://dx.doi.org/10.1155/2016/1480307